THE

SURGICAL ANATOMY OF THE BREAST AND AXILLARY LYMPHATIC GLANDS,

CONSIDERED WITH REFERENCE TO THE

MORBID ANATOMY AND TREATMENT OF CARCINOMA:

With a Note on the "Nitric Acid Method" of Demonstration.

(From the Surgical Laboratory of the University of Edinburgh.)

BY

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SURGICAL ANATOMY OF THE BREAST AND AXILLARY LYMPHATIC GLANDS, ETC.

THROUGH the kindness and courtesy of the Surgical Staffs of the Edinburgh Royal Infirmary and of Chalmers Hospital in supplying me with material, I have, during the past two years, examined over a hundred breasts excised for various diseased conditions. Almost without exception these have been subjected to a careful microscopic as well as macroscopic examination. With such a wealth of material, so generously placed at my disposal, I feel that I incur considerable responsibility, in that it is my duty to give some account of the observations I have had such a favourable opportunity of making. This I have endeavoured to do, firstly, in the Surgical Prize Essay, Royal College of Surgeons of Edinburgh 1891, and subsequently at a special meeting of the Edinburgh Medico-Chirurgical Society in January of this year, when I gave a lime-light demonstration of a series of Photomicrographs (made by Mr Andrew Pringle of London) from preparations I had made to illustrate some further observations regarding the pathology and treatment of carcinoma of the breast. Lantern slides were also shown of photographs of drawings of naked-eye specimens (prepared by what will presently be described as *the nitric acid method*) illustrating the surgical anatomy of the organ. I desire especially to thank Professor Chiene for so liberally providing the surgical laboratory with whatever was necessary to carry out the work, and for the interest he has taken in it.

A knowledge of the pathology and morbid anatomy of the mamma is essential to the correct diagnosis and successful treatment of its numerous diseases. As regards the breast, it is especially important to possess a proper conception of its anatomy under various conditions, in order to understand its pathology and adopt a satisfactory mode of treatment.

The descriptions of the mamma which are to be found in our works on anatomy do not appear to me to meet the requirements

of the surgeon. I propose, therefore, in this paper to direct attention to those points in the anatomy of the mamma which are more especially of surgical importance. The methods of studying the breast hitherto employed, namely, by dissection, with or without previous boiling or partial maceration, are neither convenient nor satisfactory. The parenchyma, or gland tissue proper, is so intimately connected with the fibrous framework or stroma, that the two cannot be separated. Again, the breast tissue is not compacted into an encapsulated body, but is so broken up and branched at its periphery that the stroma becomes directly continuous with the connective tissue framework of the fatty superficial fascia. . There is, therefore, no "capsule" in the ordinary sense of the term, except, perhaps, during lactation, when, however, the surgeon is seldom called upon to excise the breast. When presented to him for removal, the parenchyma relatively to the stroma and fat is scanty and difficult to recognise. In order to study the anatomy of the mamma a method is required which will reveal and differentiate to the naked eye its various constituents in an undisturbed relation, so that their form, extent, and arrangement may be accurately defined. Such an agent will be found in a mineral acid, especially nitric acid. Nitric acid was first brought under my notice practically by Mr George Brook, while I was working at the development of the mamma in the Embryological Laboratory of the University of Edinburgh. He uses a 5 per cent. to 10 per cent. solution as a histological "fixative" for embryonic tissues. Although an admirable re-agent for this purpose, I found, by subsequent experience with it in the Surgical Laboratory, that it was unsuitable for adult tissues which are at all fibrous, as it rendered them too tough for section cutting; and even if one should succeed in obtaining sections, the microscope shows that the fibrous tissue becomes swollen and hyaline under its influence. I have used the nitric acid method for the past two years in the surgical laboratory of the University of Edinburgh, and have found it a valuable aid to the study, not only of the normal and morbid anatomy of the mamma, but also of other tissues and organs, more especially when the seat of carcinoma, or of other new formations. I propose, therefore, to refer shortly to this method before passing to the surgical anatomy of the mamma.

The mode of employing it will vary slightly according to the object in view, and to the way in which it is desired subsequently to deal with the breast. The principle is as follows:—

1. Wash the mamma in water until all the blood is removed from its surface,—an important preliminary step, since the nitric acid coagulates, and blackens the blood, and thereby obscures the appearances which the method brings out.

2. Submerge in a 5 per cent. aqueous solution of acidum nitricum, B.P.

3. Wash in running water to remove the acid.
4. Place in undiluted methylated spirit.

The *rationalé* of this treatment is that the nitric acid renders all the tissues, except the fat, opaque white, due to coagulation of their albuminous constituents. By subsequently washing in water, the connective tissue becomes translucent, homogeneous, and somewhat gelatinous. Its consistence in bulk is firm, tough, and india-rubber like. The parenchyma, on the other hand, remains more or less dull grayish-white and opaque, due to coagulation of the more highly albuminous epithelial cells. The fat is unaltered. Cancerous tissue behaves in the same way as the parenchyma, and is rendered even denser and more opaque; in very cellular cancers the tissue resembles boiled white of egg, though of a grayish colour. The characteristic arrangement of the parenchyma is generally sufficient to distinguish it from the cancerous tissue.

For anatomical and naked-eye purposes, it is best to place the breast entire, or in thick slices, in the acid solution for twenty-four hours to two or three days, renewing the solution night and morning. By this means the acid penetrates the whole gland, which is then to be washed in running water for twelve to twenty-four hours. It should then be transferred to methylated spirit, which becomes brown, and must be renewed three or four times before it will remain uncoloured. In consequence of the firm and india-rubber like consistence of the stroma, clean and smoothly cut slices may readily be made through the organ; for this reason it is often better not to slice the breast until after it has been treated with the acid. The great advantage which specimens so prepared possess over ordinary spirit preparations is that the structural differentiation which is produced remains permanent. Slices of special interest may be preserved for museum purposes in spirit, and partially embedded in plaster of Paris in flat earthenware jars, covered with a glass circle. In cases of carcinoma, the relation of the tumour to the breast, its exact limits, and the mode and extent of its infiltrations, are clearly demonstrated. Excellent black and white drawings may be made of the appearances, and afford the only illustrations I have seen in which accurate detail and differentiation of structure is shown. It is now a year ago since I first introduced the method into Professor Chiene's operating theatre, and showed how it might with advantage be applied by the surgeon at the time of operation. After using the method for a few months, Professor Chiene desired me to lay it before the American Surgical Association held at Washington in September 1891, where he brought it under the notice of Professor Dennis of New York, who opened the discussion on "Recurrence of Cancer of the Breast." Professor Dennis was good enough to make the communication for me. Since then the method has been given a thorough trial both in America and in Edinburgh, and has proved of real practical value. It is employed at the operation in the

following manner:—The breast immediately after its removal is placed (after washing off all the blood) in from one to two pints of the five per cent. nitric acid solution for about ten minutes, and then washed in running water for three or four minutes. By this means the characteristic reaction is produced upon the surface, so that outlying portions of breast tissue, portions of the carcinoma itself, or small locally disseminated cancerous foci can, if here present, readily be detected. The examination can easily be completed before the time arrives for suturing the wound. The surgeon is thus afforded an additional means of ascertaining the limits of the disease and of the organ, and therefore of estimating more satisfactorily than hitherto the extent to which the parts should be removed in order to reach "an atmosphere of healthy tissue."

In by far the greater number of breasts I have examined, the nitric acid method has revealed the existence of lobules of the parenchyma on the surgeon's cut-surface, showing that the whole organ had not been removed. The reason for this will be found to be the result of an imperfect view of the anatomy of the breast. Pathologists are not agreed as to the part played by the parenchyma (when not entirely removed) in the production of "recurrence" after operations for carcinoma. The question is as important practically as it is interesting pathologically, and will receive consideration further on in the paper. It must be remembered, however, that although the surgeon's cut-surface may be free from disease, local recurrence may and often does occur as a result of microscopic or small macroscopic cancerous foci beyond the parts removed. In two cases operated on by Professor Chiene I was able to point out to him a speck of cancer, the size of a pin's head, exposed and cut across on the surface of the mamma far removed from the primary tumour. In both cases, by excising more tissue at a corresponding part of the wound the remainder of the diseased focus was removed, as was proved by microscopic examination. Not only in cancers of the breast, but in epitheliomata and cancers elsewhere, I have on many occasions found small outlying diseased areas exposed upon the cut surface of the parts removed. The application of the nitric acid test to parts removed for cancer points strongly to the fact that operative treatment in order to be successful must be more radical than is now the custom.

Having examined the surface of the breast, it should next be sliced, and again treated with the acid, in order that the naked-eye appearances of the gland may be studied. Future microscopic investigation of the parts is greatly facilitated by the above treatment, since, with the naked-eye structure clearly revealed, those portions of tissue can be selected which are most likely to demonstrate special histological points, and in this way much time and unnecessary labour is saved. For the reasons already mentioned, care must be taken that slices from which it is intended that pieces should be taken for microscopic examination are not

kept in the acid longer than is necessary to produce merely a surface reaction.

I now pass to consider the anatomy of the mamma from a surgical point of view.

The breast tissue consists of the following elements:—

1. The parenchyma or gland tissue proper.

2. The stroma, or connective tissue framework, which supports the parenchyma, and in which the bloodvessels, lymphatics, and nerves ramify.

3. Fat in and around the stroma.

The relative proportions of these elements vary greatly, especially according to the age of the individual, and according as the gland is, or has been functionally active. Collectively the various constituents form an organ consisting of—

(*a.*) A central part or body (the "*corpus mammæ*" of Henle[1]); (*b.*) peripheral processes.

The mamma of an adult nullipara may be taken as the type of a normal breast (Plate II., figs. 1, 2, 3). In it the corpus mammæ is well defined, and upon this the size and external configuration of the breast mainly depend. In shape it resembles very closely the ordinary bun of the pastry-cook. Its anterior surface is convex, but irregular, due to the processes which are given off from it. The posterior surface is slightly concave and more regular. The circumference is thick and well defined. If the organ be bisected vertically through the nipple in any plane, the section of the corpus mammæ presents a more or less triangular appearance, with the apex at the nipple, and the base separated from the subjacent muscle by a thin stratum of loose and delicate connective tissue. In the fresh state the stroma is tough and compact, but flabby, and of a homogeneous white appearance. The tissue of the nulliparous gland is characterised by its compact arrangement, and this is due to the small amount of fat which it contains and the close apposition of its coarse wavy fibres. Here and there an ordinary circumscribed adipose lobule, similar to that forming the subcutaneous fat, may be detected, but the more extensive admixture of fat throughout the stroma, such as is met with in multiparous breasts, does not occur. Under the nipple and areola the stroma contains no fat whatever; its fibres are loosely arranged, and allow of free mobility of the nipple, as well as of distension of the lactiferous sinuses during lactation. On close inspection, the lobules of the parenchyma may with difficulty be detected in the form of more translucent, grayish sago-like grains. In spirit preparations, the breast tissue is quite homogeneous, so that the parenchyma cannot be distinguished from the stroma. In nitric acid preparations the opaque, grayish-white parenchyma stands out in bold relief in the translucent stroma, so that its amount and arrangement can readily be studied. The ducts appear as white lines. They are

[1] *Anatomie des Menschen*, Bd. ii. p. 549.

collected into a bundle running in the vertical axis of the nipple to the summit, where they open by minute separate orifices at the bottom of a small depression. In the loose tissue under the areola they are widened out, to form the lactiferous sinuses and receive small ducts derived from the adjacent gland lobules. As the ducts extend towards the periphery of the gland they become finer and more branched, until finally, on entering the ultimate lobules they are microscopic in size. Some of the branches are prolonged beyond the body of the gland into the peripheral processes. In relation to the ducts, and scattered throughout the substance of the corpus mammæ, are numerous opaque, grayish-white, granular looking bodies from 1–2 mm. in size (Plate II., figs. 2 and 3 *b*). These are the ultimate lobules of the parenchyma, made up of microscopic flask-shaped, or short tubular gland acini opening into a common infundibulum, which leads into a terminal and microscopic duct. These ultimate lobules are aggregated more or less closely into irregular or grape-like clusters of various sizes to form larger or compound lobules, and these again are collected into lobes by the branches of a main lactiferous duct. In this way a compound racemose arrangement is produced—the lobules being much more abundant at the periphery than at the centre of the corpus mammæ. The amount of parenchyma relatively to the stroma varies considerably in different nulliparæ (compare figs. 1 and 2, Plate II.), and even in the same breast the ducts of one hemisphere or of one quadrant may possess numerous lobules, whilst the rest of the organ remains in the condition in which it is found at puberty, viz., with the parenchyma represented almost entirely by a much branched system of ducts (Plate I., fig. 1).

The peripheral processes of the corpus mammæ are relatively small in the nulliparous breast. They radiate from all parts of its surface into the circum-mammary fat. Those springing from the anterior surface appear in vertical sections of the breast as triangular tooth-like processes, with fibrous prolongations ("ligaments" of Cooper) passing from their apices to the corium (Plate I., fig. 1 *b*; Plate II., fig. 1 *f*). The parenchyma is prolonged into these processes, and in thin women reaches almost up to the corium. It follows, therefore, that the surgeon who intends to excise the whole of such a gland must either sacrifice a large amount of skin, or keep so close to it in dissecting it off the mamma as to run some risk of sloughing. From the sides of the larger processes smaller secondary processes arise, and by the junction of these with others from neighbouring processes a reticular arrangement is produced, the meshes of which are occupied by the subcutaneous fat lobules (Plate II., fig. 3). After tearing off the loose retro-mammary tissue the smooth appearance presented by the posterior surface of the corpus mammæ might lead one to conclude that it gave off no processes into the retro-

mammary tissue. As a matter of fact, however, the microscope reveals the presence of outlying gland lobules, extending from the corpus mammæ into the retro-mammary tissue, up to and between the layers of the pectoral fascia. In order, therefore, to remove all the parenchyma, the retro-mammary tissue and pectoral fascia as well as the breast must be carefully dissected off the muscle. Beyond the limits of the parenchyma the stroma of the peripheral processes becomes directly continuous with the connective tissue framework of the circum-mammary fat.

The reticular arrangement of the peripheral part of the gland is not difficult to understand, when we consider that the organ is developed by a process of continuous centrifugal budding into the subcutaneous tissue from embryonic epithelial invasions derived from the epidermis. As early as the seventh or eighth week of fœtal life, a superficial mammary area is differentiated through the invasion of the mesoblastic tissue by a solid hemispherical clump of epithelial cells produced by proliferation of the cutaneous epiblast. At the twelfth week this primary epithelial invasion begins to send downwards secondary epithelial columns equal in number to the main lactiferous ducts and lobes of the future adult gland. By the sixth month these columns have penetrated almost up to the rudimentary pectoral muscle, and are slightly branched at their extremities. They are imbedded in a well-developed fibrous stroma, which is surrounded by the developing fat lobules of the subcutaneous tissue. The stroma is continuous below with a layer of condensed fibrous tissue covering the pectoral muscle, and which sends processes between its fasciculi. During the later months of intra-uterine life the primary epithelial invasion is flattened, expanded, and cupped upon the surface, due to the horny transformation and desquamation of its more superficial cells. The secondary epithelial columns become channelled and more branched. At birth the primary epithelial invasion forms the thin epidermic covering of a circular and slightly depressed area which represents the areola, under which plain muscular fibres have already made their appearances. The nipple does not develop until a few years after birth, and is due to a papillary upgrowth of the cutis around the ducts. The rudimentary corpus mammæ at birth is a well-defined and somewhat rounded body intervening between the cutis and the pectoral muscles. The parenchyma consists of sparingly branched tubes or ducts which have not yet furnished themselves with acini. The stroma consists of compact coarse fibrous tissue surrounded by, but not mixed with fat lobules. Connective tissue processes and lamellæ radiate from the corpus mammæ to become continuous with the fibrous capsules enclosing the subcutaneous fat. From birth up to puberty the breast remains in this primitive condition, and simply grows at the same rate as the body generally. At puberty, in common with the rest of the sexual apparatus, it takes on a sudden development, which

consists in a further branching and budding out of the ducts into the surrounding tissue.

The stroma of this new parenchyma is derived from the fibrous elements of the surrounding subcutaneous tissue, the fat lobules of which remain imbedded in it. At puberty, therefore, and for several years after it, the mammæ, although to external appearances well developed, contain a relatively small amount of gland tissue which in reality represents merely the excretory ducts (Plate I., fig. 1), from which the true secreting acini have yet to be developed by a still further process of budding of flask-like diverticula around the extremities of their final ramifications. The development of the peripheral part of the gland in this reticular fashion allows of the increase in size and relatively much greater development of parenchyma which takes place during pregnancy. The evolution consists in the increase both in the number and size of the gland lobules to such a degree that the peripheral processes and lamellæ are so expanded that they become approximated, and cause more or less complete absorption of the intervening fat. In this way the fully evoluted mamma comes to possess the completely parenchymatous appearance of other secreting glands which are, and always have been, functionally active. After a variable period of functional activity the changes of involution set in by which the organ returns to its resting state. The process is characterized by an extensive atrophy of the parenchyma, and a more or less abundant development of fat cells in the persistent stroma. The breast does not return to its original virgin condition, so that one has generally no difficulty in distinguishing a nulliparous from an involuted multiparous mamma. In the latter (Plate I., fig. 2) the corpus mammæ is looser in texture, irregular, and broken up, owing to the large amount of fat in the stroma. The retro-mammary tissue has undergone a fatty transformation, so that the breast is separated from the pectoral fascia by a layer of fat of greater or less thickness. The peripheral processes are large and more widespread, so that the differentiation into body and processes is less marked. After the menopause the gland lobules undergo more or less complete atrophy, so that sometimes only the ducts remain. Small cysts (involution cysts), generally multiple, and varying in size from a millet seed to a pea, are not unfrequently met with in atrophied breasts. They are generally the result of degenerative changes in the pre-existing lobules rather than a simple dilatation of the ducts. They are, therefore most numerous upon the deep surface of the organ where the gland lobules are most abundant. They contain a serous or mucoid fluid, either colourless, yellow, brown, or bluish-green. When three or four such cysts are closely aggregated, and the intervening and surrounding tissue condensed, the condition gives rise to clinical signs closely resembling "scirrhus," and may call for a diagnostic incision before the surgeon can determine whether or not the breast should be excised. The cystic condition, however,

generally wants the characteristic density and definition of outline of scirrhus, and the rest of the breast often feels coarse and knotty, from the existence of small cysts elsewhere.

As a result of the disappearance of the gland lobules after the menopause the corpus mammæ, in spare women, becomes reduced to a more or less flattened plate-like structure, which is closely related to the subjacent muscles. The boundary-line between the body and the peripheral processes is often difficult to define. The peripheral processes are greatly narrowed and attenuated, until finally they are reduced to mere threads of fibrous tissue; they do not, however, taper away uniformly, but possess irregular and sometimes extensive thickenings at the nodes of the very irregular network which they form. This condition is not due to irregular atrophy of the parenchyma, but simply to variations in the relative amount of stroma and fat at different parts. In women who become obese after the menopause the breast tissue undergoes such an extensive fatty transformation, that in spite of the very large size of the organ very little fibrous tissue remains, except in the vicinity of the nipple and areola; the rest of the breast consists of large lobules of a yellow, oily-looking fat, between which are small irregular patches of fibrous tissue united into a very wide-meshed network by narrow bands and lamellæ in which small ducts can here and there be seen. The gland acini have almost completely disappeared. If such a breast be the seat of an ordinary circumscribed carcinoma, the tumour on palpation appears to be ill-defined, and about twice its actual size.

The surgical anatomy of the mamma would not be complete without a reference to the retro-mammary tissue and pectoral fascia; indeed, from the surgeon's point of view these structures are no less important than the breast itself, and should be looked upon as part of it. In spare women the corpus mammæ is separated from the subjacent muscles by a thin layer of loosely arranged, delicate connective tissue rich in elastic fibres; the deeper layers are more closely packed to constitute the pectoral fascia proper, which is very thin, and gives off processes which penetrate between the fasciculi of the pectoral muscle. The presence in this retro-mammary tissue and pectoral fascia of outlying lobules of the parenchyma has already been referred to. No separation can be made with the knife through this loose areolar tissue without the risk of leaving behind lobules of parenchyma. In obese subjects the retro-mammary tissue is laden with fat, which forms a thick layer separating the corpus mammæ from the subjacent muscles. The fascia in such cases is so thin as scarcely to be recognised.

The lymphatics of the breast are important alike to the surgeon and pathologist. Within the gland itself they are too small to admit of a dissection, and as they are usually collapsed in normal histological preparations, they cannot be satisfactorily studied,

unless artificially or naturally injected. Langhans,[1] although failing with senile glands, succeeded in injecting the lymphatics of non-atrophied breasts to the extent of several square centimetres by means of chance puncture injections of coloured materials into the interlobular connective tissue of the posterior aspect of the gland. The injection filled a system of lymph channels, forming a round-meshed network occupying the stroma, and enclosing one or more ultimate gland lobules in each mesh. This network receives the lymph from the interacinous spaces, and is continuous with other injected lymphatics occupying the adventitious walls of the ducts, and running parallel with them towards the areola, where they open into a horizontal plexus of larger lymphatics, lying in the loose connective tissue surrounding the lactiferous sinuses. This sub-areolar plexus (Sappey[2]) communicates freely with the lymphatics of the nipple and surrounding skin.

In carcinomatous breasts the lymphatics may frequently be seen injected, as it were, with cancer cells, so that by a careful study—more especially of the spread of the cancer in the different tissues in and around the breast—one can gain a more satisfactory idea of their structure and arrangement than is to be afforded by chance and unsatisfactory artificial puncture injections. It must not be supposed, however, that in carcinoma of the mamma the lymphatics throughout the gland are extensively and continuously filled with cancer cells. The examination of many microscopic sections, both of the tumour and of the surrounding breast tissue, may fail to demonstrate cancerous emboli in the larger lymphatic vessels. In successful microscopic preparations there is no difficulty in distinguishing the cancer cells from the epithelium of the gland parenchyma, so that the relation of the one to the other can easily be made out. The cancer cells invade first the lymph spaces of the tissue, and, since they probably possess no independent or amœboid movement, their entrance into the lymphatic vessels is more or less accidental. I have repeatedly seen lymphatic vessels containing cancer cells in all the situations in which Langhans has artificially injected them. When the perilobular and periductal lymphatics are filled with cancer cells, an appearance is produced which has erroneously been ascribed to a direct cancerous transformation or degeneration of the epithelium of some of the acini of a gland lobule. In cancerous breasts in which the tumour is closely related to the areola and nipple, the lymphatics surrounding the main lactiferous ducts are often seen to form a ring of large spaces more or less filled and distended with cancer cells. In many cases, owing to shrinkage of the cancerous emboli, the endothelial lining of the lymphatic vessels may be distinguished as a single and continuous layer of flattened cells. Outside the endothelium, the wall of the lymphatic is

[1] *Archiv für Gynæk.*, Bd. viii. p. 181.

[2] *Traité d'Anatomie Descriptive*, t. ii. p. 827 and t. iv. p. 753.

formed merely by the connective tissue surrounding the lactiferous duct. The duct itself may be more or less compressed and altered in outline, but the epithelium lining it is generally quite normal. An atrophic cancer situated close under the nipple is liable to give rise to that form of secondary infiltration of the skin which Velpeau termed "*cancer en cuirasse.*" The association of the two conditions is accounted for by the readiness with which the cancer cells may gain access to the cutaneous lymphatics of the nipple and surrounding skin through their continuity with the sub-areolar plexus.

Besides the lymphatics which are closely related to the parenchyma, there are other intra-mammary lymphatics, which, while anastomosing with the perilobular and periductal lymphatics, are more closely associated in their distribution with the bloodvessels, which, as regards the mamma, do not run in company with the ducts. If the tissue be carefully fixed, hardened, and sectioned by the paraffin process, these lymphatics when not empty and collapsed may be identified, and their structure as well as contents studied. Their structure is exceedingly simple, consisting merely of a continuous layer of endothelium, planted directly upon the unmodified connective tissue stroma which surrounds and supports the bloodvessels they accompany. I have never seen, within the mamma itself, lymphatics which possessed definite walls containing muscular fibres. The larger bloodvessels are accompanied by two or sometimes more lymphatics occupying their sheaths. When accompanying small vessels and arterioles they are usually single, of a much greater calibre than the artery, and in transverse section are often seen to surround it almost completely. In other instances the arteriole occupies the centre of a large perivascular lymph sheath. No doubt in the majority of cases the lymphatics in histological preparations are empty and collapsed ; such as are not so, however, contain a delicate fibrinous coagulum, either alone or with a few leucocytes. When cancerous, they are generally filled and distended with cancer cells, which may or may not have invaded their walls and involved the surrounding tissue. Occasionally one may observe a lymphatic of large calibre, which is patent, containing only a few cancer cells which appear to have been floating along with the lymph stream. In such a condition the endothelial lining of the lymphatic is very distinct and quite normal. I have never seen any appearances which indicate that the endothelium of cancerous lymphatics in any way participates in the cancerous process.

The examination of a large number of carcinomatous breasts has afforded a demonstration of lymphatics containing cancerous emboli in one or more of the following situations, viz., in the connective tissue processes radiating from the tumour into the surrounding breast tissue or circum-mammary fat ; in the breast

tissue, remote from as well as close to the tumour; in the connective tissue septa, separating the lobules of the circum-mammary fat; in the so-called "ligaments of Cooper," where they often lead to small disseminated cancerous nodules in the corium; in the retro-mammary tissue and pectoral fascia. In the last-named situation they are large, and generally accompany the bloodvessels which pass to and from the deep surface of the mamma.

With the above facts before us regarding the structure of the lymphatics, and the different situations in which we may observe them, we have now to consider the mammary lymphatic system and its circulation as a whole. Unfortunately here, as well as elsewhere in the body, our knowledge of the lymphatic circulation is very imperfect. What I have to say regarding this subject in the mamma is based upon the above anatomical facts, combined with a clinical and pathological study of the lymphatic dissemination of cancer as it occurs in this organ. Sappey describes the lymphatics of the mamma as consisting of—(1), a superficial or cutaneous set; (2), a deep or glandular set, embracing the lobules and lobes of the gland. He considers that all the trunks springing from the latter system pass from the posterior surface, and from the thickness of the gland towards the areola, where they form a plexus remarkable for the large size of its component vessels. From this sub-areolar plexus pass two, sometimes three, large trunks which empty themselves into the glands of the axilla. Langhans, on the other hand, holds that the efferent lymphatics of the true gland occupy the loose retro-mammary tissue, the larger trunks frequently following the larger bloodvessels in pairs. He has injected them simultaneously with the intra-mammary lymphatics.

My own observations have led me to look upon the mammary lymphatic system as consisting of five sets of vessels, which communicate freely with one another,—(1), A superficial or cutaneous set, including those of the nipple, areola, and surrounding skin; (2), the sub-areolar plexus of Sappey; (3), intra-mammary lymphatics; (4), lymphatics of the circum-mammary fat; (5), retro-mammary lymphatics. The cutaneous and intra-mammary lymphatics (in part) open into the sub-areolar plexus which connects these two systems. The lymphatics of the circum-mammary fat constitute a part of the general superficial lymphatic system of the chest. They receive, on the one hand, the lymphatics of the true skin, and on the other hand, efferent lymphatics from the anterior surface and circumference of the mamma These lymphatics of the circum-mammary fat open into larger and deeper lymphatics placed between the layers of the deep fascia. Lastly, from the lymphatics of the deep fascia large trunks pierce its deep surface, and constitute the well-defined vessels with thin but muscular walls which pass to the lymphatic glands as their afferent vessels. The retro-mammary lymphatics (including those

of the pectoral fascia) receive all the efferent mammary lymphatics which leave the posterior surface of the gland. In this way, therefore, the efferent lymphatics of the corpus mammæ, of the fat around it, and of the nipple, areola, and skin over it, open either directly or indirectly into the lymphatics of the deep fascia, which latter accompany the bloodvessels of the gland, pierce the deep fascia along with them, and so reach the lymphatic glands which lie in groups or chains alongside them. The lymphatics from the inner part of the mamma accompany the perforating branches of the internal mammary artery to join the sternal glands placed along its trunk. The greater number, however, accompany the mammary branches of the acromio-thoracic, long thoracic, and external mammary branches of the axillary artery to open into the axillary glands. I cannot agree with Sappey in considering that the two or three lymphatic trunks leading from the sub-areolar plexus are the ultimate and only channels for the receipt of the lymph from all parts of the mamma. Such teaching is entirely out of harmony with what is observed both clinically and pathologically in carcinoma of the mamma.

Recurrence of the disease after operation is due to the non-removal of small and often microscopic foci of cancer, more or less remote from the main tumour, and depending for their origin upon the arrest and growth of cancerous emboli disseminating more or less directly from the primary tumour along the lymphatics. The importance of removing all the retro-mammary tissue, pectoral and axillary fascia, axillary fat and glands, along with the breast in all cases of carcinoma, cannot be too strongly insisted upon or too oft repeated. The anastomosis and intersection of the lymphatics are so free that it is impossible to say towards which set of glands the lymph from any given point in the breast will be conveyed. I have seen cancerous lymphatic emboli at the axillary border of the mamma when the tumour was situated in the inner hemisphere, and *vice versâ*. There is no doubt also that the lymphatics of the two breasts communicate to a certain extent through a median anastomosis of both the superficial and retro-mammary lymphatics. When both breasts become cancerous, one subsequently to the other, the disease in that affected later is, in the majority of cases, probably the result of lymphatic infection, and not a primary condition. In support of this view, I may instance the case of a patient under the care of Prof. Chiene, who presented herself with a second recurrence in the left breast, in the shape of a cancerous ulcer the size of a crown piece, occupying what corresponded to the lower and inner quadrant of the mammary area. There was a large cancerous mass in the corresponding axilla, and, in addition, two cancerous masses in the opposite or right axilla, one the size of a pigeon's egg, the other of a hazel nut. Further operative treatment was not deemed advisable; but, judging merely from clinical

examination, the right breast appeared to be free from cancer. In this case it would appear that the disease in the right axilla had been conveyed thither along the retro-mammary lymphatics, the breast itself having escaped.

When the breast is treated with nitric acid, according to the method already described, it becomes at once evident that the limits which our text-books on anatomy and operative surgery have accorded to the gland are not sufficiently wide, and that the breast-tissue extends much further in every direction than is generally supposed. The result is that surgeons almost invariably, though unwittingly, fall short of their intention to remove the entire gland.

The breast is described as extending from the third to the sixth (by some authors the seventh) rib in the vertical direction, and from the edge of the sternum to the anterior fold of the axilla horizontally.

Such a description would appear to be drawn, either from landmarks afforded by the external configuration and surface anatomy of the organ, or without account being taking of its peripheral processes. The extent to which the mamma overlies the axilla appears to have been more appreciated by the sculptor than by the anatomist. It must be clearly understood that the apparent surface limits of the mamma do not correspond to the extent to which the parenchyma is distributed within the subcutaneous tissue of the anterior wall of the thorax: indeed, in many instances it affords no indication of this. The peripheral processes of the *corpus mammæ* extend beyond—often far beyond—the surface projection of the breast; and this holds true in nulliparous as well as in multiparous women, though much more so in the latter.

In nulliparæ, the mamma projects at right angles from the chest. It is self supporting, so that there is no sulcus at the lower segment of its base. Its size depends on the amount of circum-mammary fat, as well as on the amount of breast-tissue proper. A breast which is hemispherical in form indicates a relatively large amount of circum-mammary fat, whereas one which is conical possesses a thicker *corpus mammæ* and a relatively greater amount of breast-tissue proper.

During pregnancy and lactation the breast undergoes considerable enlargement. The stroma is more succulent, and during involution undergoes a partial adipose transformation. After maternity, therefore, the firmness and compactness of the breast are permanently diminished, so that it tends to be pendulous, and a more or less well-marked sulcus is produced where it overhangs its base. In multiparæ who are, or who have been stout, the mammæ are very pendulous. When excising such a breast, it should be borne in mind that the base of the organ undergoes but little downward displacement, and therefore the operator must not be deceived as to the real limit of the upper hemisphere.

For clinical purposes, the mamma is subdivided artificially into four quadrants, by means of vertical and horizontal diameters intersecting each other at right angles at the nipple. The quadrants are named upper-inner, lower-inner, upper-outer, lower-outer respectively. Two adjacent quadrants constitute a hemisphere. For anatomical as well as for clinical purposes, descriptions may be rendered still more precise by the addition of two oblique diameters reaching the circumference midway between the vertical and the horizontal ones. We may employ these oblique diameters either alone or in conjunction with the others. When employed alone, they subdivide the breast into quadrants, which may be spoken of simply as upper, lower, inner, and outer respectively.

I have taken advantage of all four diameters in order to arrive at a more accurate knowledge of the anatomical relations of the base of the organ to the skeleton and muscles of the chest. For opportunities of verifying and defining the observations I had made in the operating theatre, I am indebted to Sir William Turner and Dr Symington. In the dead subject, the real circumference of the mamma may be mapped out by inserting pins in the chest wall at the points of farthest extension of the gland,—in other words, at the extremities of the four diameters. The vertical diameter extends from the lower border of the second rib to the sixth costal cartilage at the angle where it begins to sweep upwards to the sternum; the horizontal, from a little within the edge of the sternum opposite the fourth rib or interspace to the fifth rib or interspace opposite the mid-axillary line. The one oblique diameter extends from the upper border of the third costal cartilage a little without the sternum downwards and outwards to the seventh rib a little in front of the mid-axillary line; the other oblique diameter passes from the third rib a little beyond the anterior axillary fold downwards and inwards to the sixth costal cartilage midway between its angle and its sternal end. The circumference of the organ may be defined by connecting together the extremities of all the diameters. When the arm is elevated, as for an operation, the nipple in a nullipara is placed opposite the fourth rib or interspace, and only about one inch within the axillary border of the pectoralis major, thus showing that the extent to which the breast overlaps the muscle is very considerable. The level of the breasts varies somewhat according to the configuration of the chest,—thus tall women generally possess a low bust, while short, broad-chested women have usually a high bust.

The above limits, though considerably wider than those given in our anatomical and surgical works, are certainly not exaggerated; and the surgeon cannot hope to remove the whole of the breast-tissue unless in conducting his operation he keeps outside of them. It is important, therefore, to ascertain the relations of the entire mammary area to the muscles of the chest-wall, since these afford

the surgeon's important guides in estimating the extent of his operation. In describing these deep relations we shall again make use of the various diameters subdividing the mammary area. The inner hemisphere rests almost entirely on the pectoralis major; at its lowest part it extends beyond the lower edge of this muscle, and slightly overlies the aponeurosis of the external oblique of the abdomen. The outer hemisphere has less simple relations, and must be dealt with in segments. The upper half of its upper quadrant rests on the greater pectoral, on the edge of the lesser pectoral, and, for a slight extent, on the serratus magnus, upon which, and under cover of the pectoralis major, it extends upwards into the axilla as high as to the third rib. Spence was in the habit of referring to this prolongation as the "axillary tail" of the mamma. The circumference of this segment crosses the edge of the pectoralis major at the level of the third rib,—that is, just where the muscle leaves the chest-wall to form the anterior axillary fold. The lower half of the upper quadrant, and the upper half of the lower quadrant, rest almost entirely on the serratus, with the exception of a small area adjacent to the nipple, which overlies the pectoralis major. The lower half of the lower quadrant has relation to the digitations of the serratus and external oblique which arise from the fifth and sixth ribs, and the part near the nipple lies on the pectoralis major. It will thus be seen that about one-third of the whole mamma lies inferior and external to the axillary border of the pectoralis major. Of this portion the upper half overlies the lower part of the inner wall of the axilla, and is separated from its contents only by the axillary fascia, which is here very fatty, so that the lymphatic glands lying imbedded in it appear to be in direct contact with the breast.

I now pass to the axillary lymphatic glands. These are so intimately associated with the mamma, both anatomically and functionally, that they call for an equal share of attention. They are described as follows in Quain's *Anatomy* (tenth edition, vol. ii., part ii., p. 556):—"The axillary glands are generally twelve or more; they vary much, however, in their number, as well as in their size, in different individuals. From four to six are placed along the axillary vessels, and receive the lymphatics which ascend from the limb; four or five small *pectoral glands* lie further forwards on the serratus magnus near the long thoracic artery, at the lower border of the pectoral muscles, and receive the lymphatics from the mamma and front of the chest, while three or four subscapular glands are situated at the back of the axilla along the subscapular vessels, and are joined by the lymphatics from the back. One or two small *infra-clavicular glands* are also found immediately below the clavicle in the hollow between the pectoralis major and deltoid muscles; they receive some lymphatics from the outer side of the arm and shoulder, and are connected above with the inferior cervical glands, below with the axillary glands. The efferent vessels of the

axillary glands ascend with the subclavian vein, and form by their union in some cases a single trunk (axillary lymphatic trunk), in others two or three large vessels, which terminate on the left side in the thoracic duct, on the right side in the right lymphatic duct. Sometimes they open separately into the subclavian vein near its termination."

In the normal condition, one is rarely able to feel any glands through the coverings of the axilla. In morbid conditions of the breast, the pectoral glands are almost invariably the first to undergo enlargement. In the later stages of carcinoma all four groups may be diseased, but generally the humeral and subscapular groups escape. Occasionally, the glands above the pectoralis minor, in the apex of the axilla, and under the clavicle, are diseased, while the pectoral glands are normal. This points to the probability that some of the lymphatics from the mamma pass to join the glands at the upper part of the axilla directly, without entering the pectoral group; and, as far as my observations go, this would appear to be the case when the tumour is central, and more especially when the skin about the nipple and areola is implicated. Some of the lymphatics which are efferent for the pectoral glands, become afferent for glands higher up towards the apex of the axilla.

When the parts which have been removed from the axilla (in connexion with mammary operations) are carefully examined, one is struck with the great variation in the appearance as well as in the number of the glands. As many as twenty, thirty, or even more may not infrequently be counted when the axilla has been thoroughly cleared out. The reasons for the anatomical underestimation of the number of glands in the axilla are, that some measure not more than one or two millimetres in diameter, while others have undergone such an extensive fatty involution as to resemble closely an ordinary fat lobule. What may be regarded as the typical glands vary from about the size of a grape stone to that of a small pea. In the region of the hilus the lymphoid tissue becomes replaced by a greater or less amount of fibrous tissue, which serves to support the main divisions of the blood-vessels and efferent lymphatics; and from this connective tissue processes are given off which ensheath the vessels, and in their turn give origin to the delicate connective tissue reticulum, in which the leucocytes of the follicular parts of the gland are entangled. The reticulum occupying the lymph sinuses is produced from the retiform branching of delicate connective tissue processes which are given off from the fibrous trabeculæ penetrating the gland from its capsule. The afferent and efferent lymphatics lose their adventitious and muscular coats where they respectively open into and out of the lymph sinuses, the endothelial lining of which is continuous with that of the lymphatics. If sections of the gland which have been stained with nuclear dyes be examined under low magnifying power,

there will be observed, scattered here and there throughout the gland, rounded foei or masses of cells which have stained less deeply than the follicular tissue generally. These are the germ centres (Keimeentren) of Flemming.[1] They are always embedded in the lymphoid follicles, or in the lymphoid cords of the gland, and they are most numerous in the eortical region. When more highly magnified, the eells that form the centres are seen to be larger than the densely erowded lymphoid eells that surround them. A eloser comparison of the two kinds of eells shows that those forming the germ eentres possess larger and less deeply stained nuclei, and a greater amount of perinuelear substanee. These are fully developed leucocytes, in many of whieh mitotie figures may be seen: in other words, they are eentres of proliferation, the daughter eells—the small lymphoid eells—having migrated and beeome crowded together around them. These lymphoid eells find their way into the lymph sinuses, and ultimately reach the blood as young leucoeytes.[2] In examining axillary glands for malignancy, it is important that one should be familiar with these germ eentres, otherwise they might be mistaken for eancerous foei.

Having referred to the essential points in the microscopic anatomy of a gland, I wish now to deseribe one or two departures from the normal type. Although these have been studied mainly from material derived from patients suffering from carcinoma of the mamma, I may state that I have also met with similar eonditions apart from eancer, and in other regions of the body; for example, in the neek, the anterior mediastinum, the groin, and the popliteal space. No doubt they oeeur throughout the body generally.

In the first place, the very minute glands, whieh do not exceed one or two millimetres in diameter, possess a very primitive structure, and afford a elear demonstration of the essential parts of a gland. Here we have to deal merely with a single lymphoid follicle, between which and the connective tissue capsule is an unbranehed lymph sinus eonnected with only one afferent and one efferent lymphatie. A germ centre may sometimes be observed in the centre of the folliele, thus proving that these little glands are funetionally active. They correspond elosely to the endolymphangial nodules which Klein[3] has deseribed as occurring in the serous membranes. They differ from the solitary glands of the alimentary and respiratory mneous membranes in the possession of a distinet eapsule, whieh is doubtless the thiekened wall of the original vessel, inside of which the follicle has developed.

[1] "Studien über Regeneration der Gewebe," *Arch. f. Mikr. Anat.*, vol. xxiv., 1885.

[2] For further details as to the functions and origin of these structures, Gulland's paper "On the Function of the Tonsils," *Edin. Med. Journal*, 1891, may be consulted.

[3] *The Anatomy of the Lymphatic System*, part i.

Secondly, the glands, which have undergone a more or less complete fatty involution, are found in variable numbers during the resting state of the mamma, both before and after the menopause. Their size also varies greatly. They may be no larger than a grape stone, or they may reach the size of a filbert, or may be even larger. Their number and size are greatest in women who have become obese after the menopause, and whose breasts have therefore undergone very extensive fatty transformation. The naked-eye appearance of a bisected fatty involuted gland is peculiar and characteristic. It differs markedly both from that which is presented by a typical lymphatic gland on the one hand, and by an ordinary fat lobule on the other. The hilus is represented by a more or less distinct notch, opposite which, and immediately under the capsule, is a narrow crescentic layer of lymphoid tissue, occupying the whole or a greater part of the circumference of the gland. The extremities of the crescent often curve into the substance of the gland at the hilus. This lymphoid tissue possesses a uniform grayish-pink and fleshy appearance, resembling granulation tissue. Within the lymphoid crescent, and forming the bulk of the gland, is the fatty portion, which is softer and more bulging. It differs, however, from ordinary fat, both in appearance and in consistence. It is firmer and has a pale grayish colour, almost without any yellow tint, and with but little of the oily aspect of ordinary fat. The interpretation which has, I believe, frequently been given of these appearances is that the firmer, more vascular, grayish-pink concentric zone represents the cancerous portion of a malignant gland, while the fatty medullary portion is looked upon as the remains of the normal gland tissue. Microscopic examination, however, at once reveals the error. At first sight one gets the impression that the structure is not a lymphatic gland at all, but is merely an ordinary fat lobule, the peripheral portion of which is occupied by an inflammatory leucocyte infiltration. Further investigation shows that every stage of transition exists between almost complete fatty metaplasia and what may be looked upon as a typical lymphatic gland. The earliest sign of fatty involution is evinced by a fatty metaplasia of the cells of the connective tissue in the region of the hilus; next, the connective tissue framework of the medullary part of the gland becomes involved; and, finally, the whole gland, with the exception generally of an incomplete and very thin layer immediately under the capsule, becomes converted into adipose tissue. The lymphoid tissue that remains is always the cortical portion, the follicles of which may still contain germ centres, showing that the gland is not completely functionless. A distinct lymph sinus (subcapsular sinus) containing a retiform network intervenes between the capsule and the lymphoid tissue, and is continuous with other sinuses that surround the connective tissue trabeculæ penetrating the gland from the capsule. These, again, are continuous with lymphatic channels which run from the

inner margin of the lymphoid zone through the fat towards the hilus, where they unite to form wider channels which emerge at the hilus as the efferent vessels. Afferent lymphatics may be seen opening into the subcapsular sinus, just as in an ordinary gland. The microscopic appearances of the fat differ from that of an ordinary fat lobule, not only in possessing many large lymph channels, but also in the correspondingly large number and size of the bloodvessels which pass to and from the hilus. The presence of so many large blood and lymph vessels in the fat accounts for the more porous, more vascular, more serous, and less oily appearance which distinguishes it from ordinary fat.

In order to understand the manner in which this fatty involution or metaplasia is brought about, and the conditions in which it occurs, we must remember that these lymphatic glands are associated both functionally and anatomically with the mamma. In a former part of this paper I showed that the mamma undergoes important structural alterations in relation to its various functional states. The process of involution of the mamma, whereby it passes from the condition of full functional activity to a state of rest, is attended not only by partial atrophy of the parenchyma, but also by a conversion of much of the connective tissue into fat. After the menopause, the more or less complete atrophy of the parenchyma is, except in spare women, accompanied by a still further fatty transformation of the stroma; and in obese women very little of the original stroma remains.

The fatty involution of the axillary glands corresponds exactly to the process above described in the mamma; that is to say, we have an atrophy and absorption of the follicular tissue, along with a fatty metaplasia of the connective tissue framework.

During the functional state of the mamma, the lymph which is drained from it to the glands is greater in quantity and altered in quality as compared with its resting and atrophied state. There is an increase both in the deposit and in the production of leucocytes in the lymph glands, the increased production being shown by the large number and size of the germ centres present.

During the resting condition of the mamma, and still more after the menopause, the deposit and production of leucocytes within the lymphatic glands are very slight. More leucocytes are washed out of the glands by the circulation of the lymph through them than are conveyed to them or manufactured in them. Accompanying this decline of function, and no doubt in some way associated with it, is the fatty transformation of the connective tissue framework. The cortical part of the gland, which is always the most active functionally, is the last to undergo the change.

This fatty involution or metaplasia of lymphatic glands appears to me to afford a field for speculation and further study, especially in its possible relations to such diseases as lymphadenoma, tubercle, syphilis, etc. It is not difficult to account for the large number

of glands which come into prominence in these diseases, as compared with the number which anatomists describe as existing normally, if we consider that many of the glands which have become enlarged are such as had normally undergone fatty involution, but which, as a result of the irritation to which they became subject in these diseases, have again become evoluted and diseased.

The fatty involuted axillary glands are of interest to the surgeon both clinically and pathologically. As a rule, palpation through the coverings of the axilla gives no indication of their presence, although occasionally, when large and numerous, they give rise to what is often spoken of as a "fulness in the axilla." They are usually discovered when the axilla is explored from the wound made to excise the breast, and are then spoken of as "enlarged glands," and, as I have already pointed out, are either regarded as maliguant, or are looked upon with the greatest suspicion. In stout women, their resemblance to an ordinary fat lobule is such that they are liable to be overlooked by the surgeon who is content with exploring the axilla with the view of discovering and "shelling out" only those glands that are distinctly indurated. During the operation, they may be distinguished from fat lobules by three positive characters, viz,—(1.) When grasped between the finger and thumb they are firmer and more elastic; (2.) They possess a distinct capsule which enables them to be readily shelled out from the surrounding fat; (3.) During their removal, the blood and lymph vessels connected with them are brought into view, and have to be torn or cut across before they can be completely separated. The larger they are, the thinner and more stretched is the capsule. Their greater firmness and elasticity as compared with an ordinary fat lobule are due to the greater tension under which the fat and the lymph are confined within the capsule.

When one of these glands is treated with a five per cent. solution of nitric acid, the cortical zone of lymphoid tissue becomes dense and opaque white, and remains so after being subsequently washed in water. The fatty portion is unaltered. By this means, therefore, the true nature of the gland is clearly revealed. In a previous part of this paper I showed the value of the nitric acid method in differentiating cancerous tissue in the breast. It is necessary to point out, however, that the same method does not render the detection of cancer in a lymphatic gland any easier than it would be in the fresh and natural condition, since the lymphoid tissue, on account of its highly cellular and therefore also highly albuminous nature, reacts to the nitric acid in much the same way as cancerous tissue.

Microscopic examination of fatty lymphatic glands, which have been removed along with a cancerous mamma, shows that the fatty part of the gland is being invaded by leucocytes, especially along the lines of the blood and the lymph vessels. This leucocyte infiltration is accompanied by a connective tissue and endothelial

proliferation, especially noticeable at the invading edge. It would appear, therefore, that the irritation and cell activity which is going on in the mamma so affects the axillary glands as to produce an evolution in them, whereby they become converted again, more or less completely, into lymphoid tissue. The transformation, when complete, results in what is spoken of as a "simple" enlargement of the gland. The simple enlargement of the glands, which is often associated with the presence of simple neoplasms, cystic disease, chronic mastitis, etc., is no doubt brought about in the same way from glands which have undergone more or less fatty involution. The same glandular enlargement may be observed in other regions of the body, when the parts from which the lymph is derived are under similar pathological conditions.

Some surgeons are inclined to look upon all glandular enlargements associated with carcinoma as necessarily malignant. Such a view, while incorrect pathologically, errs on the safe side from the therapeutical point of view. Professor Chiene has long been in the habit of pointing out that this simple enlargement of lymphatic glands is especially liable to be associated with malignant disease when attended with ulceration and sepsis, and that when the tumour is removed the glandular enlargement disappears. I have on several occasions microscopically examined enlarged (often much enlarged) glands removed from the axilla, neck, and groin, in cases of malignant disease of the breast, tongue, and penis respectively, without discovering any cancer in them. Such enlarged glands may or may not be the seat of acute or chronic inflammation. When acutely inflamed they are only slightly indurated, of a red or reddish-purple colour, and often mottled with minute hæmorrhages. Vascular engorgement, rupture of capillaries, and choking of the lymph sinuses with leucocytes and red blood corpuscles, express the microscopic appearances. Simple enlargement with chronic inflammation gives rise to greater induration; the inflammatory hyperplasia affects especially the connective tissue framework of the gland, which is often seen to have undergone a marked hyaline degeneration. The lymph sinuses contain proliferated connective tissue and endothelial cells, rather than leucocytes. Glands of this description are frequently found where the breast is the seat of a simple tumour of cystic disease and of chronic mastitis. In the circumscribed variety of the latter disease their presence only serves to add in some cases to the difficulty of distinguishing it from carcinoma.

While I have hitherto spoken of the fatty glands as originating only from pre-existing glands, I am not prepared to say that this is the only way in which they are produced. On the contrary, there is evidence to show that they may possibly also be developed simply from fat lobules, which are more closely related to the lymphatics than usual, in the same way that some fat lobules possess a distinct afferent artery and efferent vein

united by a capillary network occupying the substance of the lobule. In the breast itself, especially when the seat of a rapidly infiltrating carcinoma, I have certainly observed the formation of lymphoid nodules and germ centres in connexion with the perivascular lymphatics of a small artery and vein, which occupied a delicate connective tissue lamella of the intra-mammary fat. A similar new formation of lymphoid tissue occurs sometimes at certain points around the vessels and lymphatics which lie between the fat lobules of the axilla.

Lymphatic glands, when cancerous, are frequently so extensively diseased that no trace of the original lymphoid tissue remains. When this is the case, they are characterized clinically by marked induration, and usually by enlargement. Occasionally several cancerous glands are matted and conglomerated into a mass of the size of a child's fist. In cases where the disease is confined to the medullary part of the gland, the cortical region responds to the irritation produced by the cancer, the result being an increase in the number and size of the germ centres, and a dense accumulation of lymphoid cells (young leucocytes) around them. All the varieties of lymphatic glands I have referred to may be cancerous,—that is to say, may contain cancer cells. Theoretically the initial stage of the disease consists in the deposit in the gland of a single cancer cell, which has been conveyed to it from the cancerous mamma along the lymphatics. Although it is practically impossible actually to demonstrate this, one may nevertheless observe the condition in which only a few cancer cells exist in the gland; they generally occupy the subcapsular sinus, that is, just the place where anatomically we should expect to find them. I possess a microscopic section of a fatty lymphatic gland showing this state of affairs. The preparation was made to show the normal structure of the gland, which, to the naked eye, appeared to be absolutely healthy. Such a gland, in consequence of the fatty change which it has undergone, feels even softer than a normal gland when made up entirely of lymphoid tissue. It follows, therefore, that the absence of induration does not always signify freedom from malignancy. Again, it must be remembered that the smallest glands are sometimes malignant. As in this condition they may be no larger than an ordinary pin's head, the absence of enlargement does not necessarily imply non-malignancy.

The main lymphatic trunks of the axilla run for the most part alongside of the bloodvessels. In consequence, however, of their small size and the thinness of their walls, it is difficult to display them by dissection. The afferent vessels of a gland are more numerous, but smaller than the efferent. The microscopic structure of the wall of a lymphatic trunk closely resembles that of a small vein. Indeed, when they are isolated and empty it is sometimes difficult to say with which one is dealing. If, however, the lymphatic is lying side by side with bloodvessels,

it may be recognised by its more or less collapsed, longitudinally folded, and relatively thin wall. The lumen is small and stellate, and is either empty or contains a little granular matter and a few leucocytes. Judging from the extent to which the wall is folded, the calibre of the vessel when distended must be very large relatively to the thickness of the wall—a relationship which appears to hold true throughout the lymphatic system generally. As regards the coats of the lymphatic, one fails to detect the well-marked differentiation between the muscular and the adventitious layers. In the small arteries the middle coat is purely muscular and the outer purely fibrous. In the veins there is a considerable admixture of fibrous and elastic tissue between the muscular fibres of the middle coat. In the lymphatic trunks the whole thickness of the wall outside the internal coat is made up of a mixture of muscular and fibrous tissue in about equal proportions. The muscular fibres are collected into small bundles separated from one another by the loosely felted white and yellow connective tissue fibres. Another distinguishing feature of the lymphatic is that the muscular fibres, instead of all running circularly, as in the case of the bloodvessels, run many of them longitudinally. The majority of the circular fibres lie internal to the longitudinal, but frequently the two sets of fibres are mingled. Valves, consisting of two opposed segments, are placed at frequent intervals along the main lymphatic trunks. They consist of a reduplication of the endothelial layer of the vessel. A transverse section opposite the valve gives the appearance of a treble lumen to the vessel, the middle compartment being bounded on either side by the section of a segment of the valve which is so extensively pleated as to present a very zig-zag edge, thus showing how greatly distended the vessel would have to become before the valve became incompetent.

The important part played by the lymphatics in carcinoma of the mamma has already been referred to. Surgeons are in the habit of indicating their cognisance of this fact by sometimes referring to a "thickening" of them, which may be felt, not only when the axilla is opened up, but even through its coverings. As the result of the examination of the parts removed from over a hundred axillæ in cases of cancer, I am satisfied that the lymphatics are in no way responsible for this stringy feel. The condition is felt most distinctly in spare women with more or less atrophied breasts, and is due to the presence of the ducts of the breast tissue, which run like so many branched strings under the edge of the pectoralis major, and upon the surface of the serratus as high up in the axilla as the third rib. They are, in fact, the ducts belonging to what Spence used to speak of as the "axillary tail" of the mamma. That this is the case may readily be demonstrated by stripping off the fascia from the posterior surface of the breast (with which the

axillary tissue is left in contact), and then by applying the nitric acid method to it. The structures which give rise to the stringy feel will appear as opaque white lines, which may occasionally be traced as far as the cancerous glands. Microscopic examination shows that they are mammary ducts and not lymphatics. One may examine both macroscopically and microscopically the tissues from many cancerous axillæ without being able to discover any disease whatever in the lymphatic trunks. It is evident, therefore, that as soon as the cancer cells reach lymphatics of any size, they are swept along them to the glands, in the same way that an embolus is washed along a vein. The lymphatics do not always escape in this way, because stationary cancerous emboli are frequently present in the smaller vessels, and of course can only be discovered by microscopic examination. They subsequently invade the wall of the lymphatic, and give rise to nodules of cancer which are distinct from the lymphatic glands. In the comparatively few cases in which I have found the main trunks diseased, the cancer cells could always be traced as far as a malignant gland, the lymph sinuses of which, in consequence of being blocked, had no doubt caused a heaping up of the cancer cells behind them.

It is very doubtful whether a cancerous condition even of the largest axillary lymphatics can be detected during the operation. Examined microscopically, the wall is seen to be thickened—a condition due to chronic lymphangitis. The lumen is filled with cancer cells. To the naked eye, therefore, such a diseased lymphatic resembles a small bloodvessel which has been plugged or obliterated.

After describing the anatomy of the parts concerned in carcinoma of the mamma, a number of photographs were shown to illustrate the manner and extent of their involvement in the disease. As regards the tissues extrinsic to the mamma, viz., the skin, subcutaneous fat, pectoral fascia, and muscles, the preparations show conclusively that their diseased condition consists in the presence of cancer cells here and there in their lymph spaces and lymphatic vessels. The cancer cells do not originate from the cell elements of these tissues; they are the descendants of pre-existing cancer cells, and have been conveyed thither by the lymph stream, and occasionally also by the bloodvessels. The inflammatory connective tissue hyperplasia, attended with more or less leucocyte exudation, is a secondary element in the disease. The term "recurrent," applied to the disease which manifests itself after operation in these extrinsic structures, is obviously a misnomer, since what really occurs is a continuance of the original disease which was already present at the time of the operation, and which in the course of its life history becomes, from a structure visible only with the microscope, a palpable nodule. I have already shown how seldom all the gland tissue is removed in operations for cancer of the breast. The question, therefore, arises, "What part does

the breast tissue that has been left behind play in the production of recurrence?" Surgeons are not agreed on this point, and herein lies the difference of opinion that exists regarding the necessity of removing the entire breast in all cases of carcinoma.

Mr Butlin,[1] in arguing against radical operations as a *sine qua non*, says,—"Certainly in the majority of instances there is nothing to lead one to believe that the new growth arises in the outlying lobules of the mammary gland, or in any remains of the parenchyma of the gland." Heidenhain,[2] on the other hand, in a very admirable paper, read before the German Congress of Surgeons in Berlin in 1889, maintains that in carcinoma of the mamma there are proliferative changes in the lobules throughout the whole gland, which must be looked upon as the direct forerunner of cancer ("das mittelbare Vorstadium der Krebsentwickelung"), and that sooner or later will pass into typical cancer.

My own observations on the causes of recurrence of cancer of the breast lead me to take up an intermediate position. I hold that when cancer manifests itself in breast tissue which has been left behind, the disease originates in the majority of cases from pre-existing cancer cells derived directly or indirectly from the original tumour, and occupying the lymph spaces or lymphatics of the stroma. In other words, "recurrence" in breast-tissue which has been left behind originates in the same way as "recurrence" in the tissues extrinsic to the mamma and in the axilla. While admitting that recurrence may originate from the epithelium of mammary acini which has been left behind (just as the original tumour has arisen from mammary epithelium), I maintain that it does not necessarily do so; on the contrary, I believe it to be a quite exceptional cause of recurrence. I am familiar with the various conditions which Heidenhain[3] refers to as existing in the acini and lobules, both adjacent to the tumour and to the "surgeon's cut-surface." The conditions which he looks upon as pre-cancerous present histological appearances which are very different from those of cancer proper. In the case of many breasts they are not only altogether absent, but when they do occur the most careful examination of all parts of the organ fails to detect the transitional stages of their development into cancer; moreover, these so-called pre-cancerous conditions are also met with in breasts which are the seat of chronic mastitis, cystic disease, etc. I would therefore advocate that the principle which should underlie all operations for carcinoma of the mamma (or carcinoma wherever situated) is the complete removal, not only of the tumour and the organ in which it lies, but also of as much of the surrounding tissues as is likely to contain the lymphatic spaces and highways along which

[1] *The Operative Surgery of Malignant Disease*, p. 378.

[2] "Ueber die Ursachen der localen Krebsrecidive nach Amputatio Mammæ," *Verhandlungen der Deutschen gesellschaft für Chirurgie*, Berlin, 1889.

[3] *Loc. cit.*

the malignant elements of the disease (as far as our present knowledge goes—the cancer cells) have been disseminated. Unfortunately, it is impossible in any given case to say to what extent this may have taken place. Here exactly lies the difficulty and uncertainty of the operative treatment of malignant disease. Much, however, may be done by a more careful study of the histological relations of the tumour elements to the organ, and especially to the lymphatics of the part in which it is situated. In the present state of our knowledge the surgeon will do well to err on the side of sacrificing too much rather than too little tissue.

Professor Dennis,[1] in his paper on "Recurrence of Carcinoma of the Mamma," admirably puts the case when he says,—"The recurrence of carcinoma of the breast is influenced by the radical character of the operation itself. No procrustean rule can be laid down in regard to the extent or character of the operation for the removal of carcinoma of the breast which would meet the exigencies in every case. There is, however, a standard operation which is none too severe to meet the necessary conditions in every case. The uniform classical operation should include the entire breast gland, all the fatty areolar connective tissue in the vicinity, the integuments over the circumscribed area of the tumour, and as much more as is necessary, leaving out of consideration altogether the question of flaps to cover the wound, and, finally, the pectoral fascia." In another part of the paper he again refers to this as follows:—"I am a strong advocate of always removing in every case, to which there is no exception, the entire breast, with the pectoral fascia and the lymphatic glands, as the minimum operation in the most insignificant scirrhus. The operation in nearly all cases must extend beyond the limits of the breast, and include a most radical one."

It is worth while to inquire how this "standard" and "minimum" operation should be carried out in order to give the best chance of removing all the disease with, at the same time, the least amount of mutilation. The first and perhaps the most important step in the operation is to make suitable skin incisions. Although these must vary with the position of the tumour and the amount of skin invasion, there is nevertheless a definite principle to be followed in all cases, and that is so to plan the incisions as best to facilitate the removal of the entire organ, and at the same time of whatever skin is diseased or is at all likely to be so. Let us take, for example, the case of an ordinary circumscribed scirrhus, with the skin over it not obviously involved. According to Gross,[2] the plan to adopt would be "to carefully palpate the entire mammary region while the patient is supine, in order to discover any outlying lobules, should they exist, and then with an aniline pencil to draw a line round the entire circumference of the

[1] *Trans. of the American Surgical Association*, vol. ix. 1891, pp. 226 and 229.
[2] Mann's *System of Gynecology*, vol. ii. p. 314.

breast as a guide for the knife. If the tumour be peripheral, the incision must extend for at least one inch beyond its apparent limit. A stout large knife is then carried along the line down to the pectoral muscle." Such a method, in my opinion, is open to great objection. In the first place, from what has been said of the arrangement and extent of the breast, it is obvious that the circumference of the gland cannot be defined by palpation. Gross's "circle" will be considerably smaller than that formed by the real circumference of the gland, so that to cut directly down along it to the pectoral muscle would necessarily leave behind more or less of the peripheral processes of the gland. Such a method, besides leaving behind breast-tissue, and removing too little of the circum-mammary fat, is open to the objection that it sacrifices an unnecessary amount of skin. In a simple case, such as that we are referring to, it is quite unnecessary to remove a large circle of skin. The old elliptical incision, if sufficiently large, is the best incision to employ, so far as the removal of the entire gland is concerned, and it should be made parallel to the oblique diameter of the mamma, its lower extremity reaching well down below the costal margin close to the ensiform cartilage, and its upper extremity terminating at the outer border of the pectoralis major opposite the third rib. The ellipse should be widest opposite the nipple, and should there measure at least four inches across. In stout patients it can be made much wider, and will still allow the edges of the wound to be brought in contact. In an obese patient recently operated on by Professor Chiene, the edges came together without difficulty, after the removal of an ellipse measuring twelve by eight inches.

The axilla is laid open by carrying an incision from the outer extremity of the ellipse along, or a little below, the edge of the pectoral across the axilla to its outer wall, as far as the angle between the lower edge of the tendon of insertion of the pectoral and the inner border of the biceps. The axillary incision should be made at the same time as the ellipse, and both should extend down to, but not through, the subcutaneous fat. If the ellipse includes the whole of the skin over the tumour, the surgeon may at once proceed to reflect the flaps off the breast; but, if the tumour does not fall within the ellipse, the skin over it should be removed by a triangular incision (as recommended by Dr Joseph Bell, *Edinburgh Medical Journal*, 1871), the base of which forms part of the ellipse. This plan should be followed not only when the skin is evidently involved, but even when it is freely movable and apparently healthy. It will be obvious that unless such a method be adopted, the ligaments of Cooper, containing lymphatics in direct continuity with those about the tumour area, and therefore liable to contain cancer cells, will be left, and consequently recurrence in the skin or subcutaneous fat is liable to occur. I believe neglect of this

procedure is often responsible for the superficial recurrent nodules which are not infrequently observed in and close to the cicatrix. A combination of these incisions will be most suitable in the majority of cases in which the tumour is peripheral—the result being a T-shaped cicatrix. The lower and outer flap should first be dissected off the breast, keeping as close to the skin as is consistent with the maintenance of its vitality. This dissection should be carried as low down as to the seventh rib in the mid-axillary line. The upper and inner flap is reflected inwards beyond the edge of the sternum, and upwards almost as high as the clavicle. It is to allow of this free dissection that we recommend that the axillary incision should be made at the same time as the ellipse. The breast, with the exception of the axillary portion, should now be freed from the chest wall along with the fascia of the muscles which underlie it, viz., pectoralis major, serratus magnus, and obliquus externus. Unless the upper digitations of the latter muscle be laid bare, the probability is that some peripheral processes of the gland have been left. The axilla is dealt with by first cleaning the edge of the pectoralis major as far as the biceps; in this way the axillary fascia is divided and the axilla opened into. The axillary vein is exposed at this stage lying immediately underneath the fascia at the outer extremity of the incision. The fat and glands should be removed as far as possible *en masse*, by working in the first instance from the edges of the pectorals back to the latissimus dorsi so as to expose the serratus magnus and subscapularis. The intercosto-humeral nerves, which come into view at this stage of the operation, may be avoided, and care should be taken not to injure the two lower subscapular nerves. The dissection is then continued along the inner wall under the pectoralis minor to the apex of the axilla. Finally, the fat and any glands are to be separated from the axillary vessels; and care must be taken that branches of the axillary vein which come into view are not torn through close to the parent trunk.

As regards the treatment of the wound, if the operation be conducted according to aseptic principles, no drainage tube is required, and the case will generally not require to be dressed until the end of a week, when the stitches may be removed. If, however, strong antiseptics have been employed to douche out the wound, both before and after stitching, the copious serous exudate caused thereby, necessitates, in my opinion, the use of a drainage tube for the first twenty-four hours. The above operation is, I believe, sufficiently radical for simple cases.

When, however, the skin over the tumour is involved, its removal must include a wide margin of apparently healthy skin. When, in addition to being invaded in the region of the tumour, the skin is also the seat of multiple nodular cancerous disseminations, then the whole or nearly the whole skin over the mamma must be removed, since, in addition to the palpable nodules the *nitric acid*

method shows that there are other disseminations beyond them which are too small to be recognised by the most careful clinical examination. Professor Watson Cheyne[1] has shown the great value of grafting skin upon the pectoral muscle at the time of the operation when the wound cannot be closed. In one of his cases, in which the gap measured 8 by 6½ inches, the whole wound was soundly healed within a month. If the tumour, as is so frequently the case, be adherent to the pectoral fascia, a large piece of the subjacent muscle should be removed, even although it should appear to be quite healthy. The neglect of this procedure results not only in the exposure of a part of the surface of the tumour on the "surgeon's cut-surface," but also in the likelihood of a few cancer cells being left behind on or between the superficial fasciculi of the pectoral muscle.

When the pectoral muscle is obviously invaded by the tumour-mass, and by nodular disseminations in the vicinity, the prognosis will be most unfavourable. Heidenhain points out that the contractions of the muscle favour the spread of the cancer cells along the lymphatics, and recommends that the entire muscle be removed, but this appears to me to be unnecessarily radical.

Lastly, it will be gathered from what has been said regarding the pathology of recurrence, that a knife which has once cut into cancerous tissue should not be used again in the same operation.

[1] *Lancet*, 4th July 1891.

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Fig.1.

DESCRIPTION OF THE ILLUSTRATIONS.

All are drawn, natural size, from specimens treated with Nitric Acid.

PLATE I. Fig. 1.

Vertical slice a little below the nipple; girl, æt. 18. (Post-mortem specimen. Skin not removed.)

a. "Corpus mammæ"—the stroma is compact, and the parenchyma is represented merely by branched ducts.
b. Peripheral processes of "corpus mammæ" ending in "ligaments" of Cooper.
c. Axillary margin of "corpus mammæ," cut across in removing the organ.
d. Intra-mammary fat lobule.
e. Subcutaneous fat.
f. Retro-mammary fat.
g. Pectoral fascia.
h. Axillary border of pectoralis major.
i. Axillary fascia.
k. Axillary fat.

PLATE I. Fig. 2.

Slice from the cancerous mamma of a woman, æt. 38; married; nine children. The tumour occupied the periphery of the lower and outer quadrant; close to it was a mass of cancerous glands.

a. Nipple.
b. Sebaceous glands of areola.
c. Skin.
d. "Corpus mammæ;" parenchyma consisting chiefly of ducts.
e. Dilated ducts.
f. Peripheral processes of the "corpus mammæ."
g. Intra-mammary fat lobules.
h. Retro-mammary fat.
i. Pectoral fascia.
k. The tumour—a typical nodular scirrhus, to which the superjacent skin is tacked down.
l. Cancerous infiltration of the adjacent breast tissue.
m. Cancerous axillary glands.
n. Bloodvessel.
o. Surgeon's cut-surface (sternal edge), showing peripheral processes of "corpus mammæ" cut across.

Plate II. Fig. 1.

Slice from the cancerous mamma of a spinster, æt. 27. The tumour had been noticed 18 months, and occupied the periphery of the upper and outer quadrant.

a. Nipple and ducts.
b. Skin.
c. Subcutaneous fat.
d. Corpus mammæ.
e. Parenchyma—consisting of branched ducts from which only a few small ultimate lobules have been developed.
f. Peripheral process of corpus mammæ, ending in a "ligament" of Cooper.
g. Sternal edge of corpus mammæ cut across on surgeon's cut-surface.
h. Intra-mammary fat.
i. Pectoral fascia.
k. The tumour, which has partly invaded the superjacent skin.
l. A portion of the serratus magnus muscle to which the tumour was adherent.

Plate. II. Fig. 2.

Peripheral slice from the cancerous mamma of a spinster, æt. 39. To illustrate some points in the normal anatomy of a well-developed gland.

a. Stroma.
b. Ultimate lobules of the parenchyma arranged in grape-like clusters around the terminal branches of the ducts.
c. Connective tissue framework of circum-mammary fat (*d*).
e. Surgeon's cut-surface with (*f*) breast tissue extending up to it.

Plate II. Fig. 3.

Opposite surface of the slice illustrated in the previous figure, showing the appearance of the surgeon's cut-surface when the gland has not been completely removed. Same lettering as above.

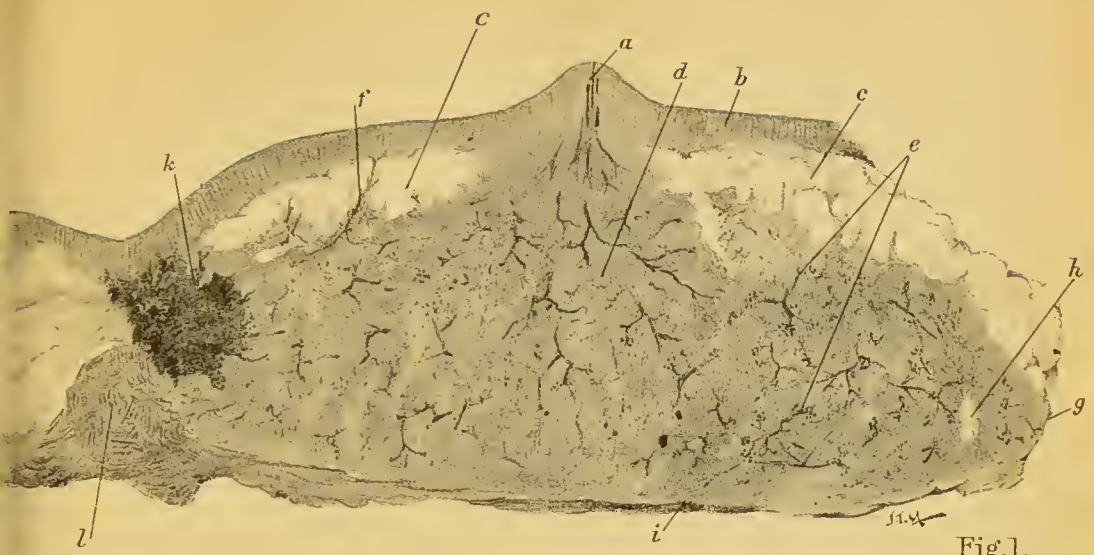

Fig. 1.

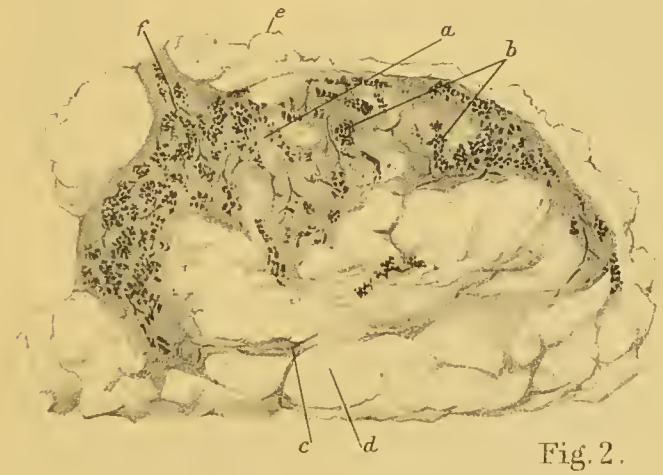

Fig. 2.

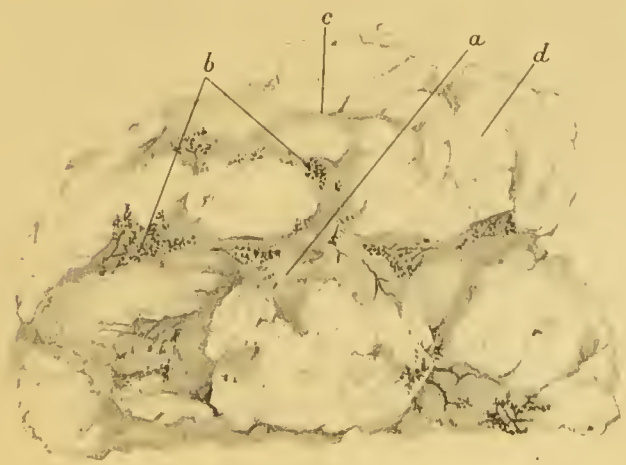

Fig. 3.